Energy Consumption Status of Public Buildings and the Analysis of the Potential on Energy Efficiency in Xiamen

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Abstract：Based on the survey on the preset and applied situation of the central air conditioning systems in public buildings in Xiamen, this paper analyzes the status of energy consumption, and indicates the irrational aspects of operation and management of the central air conditioning system in public buildings. At the same time, this paper comments on energy economization in Xiamen, and presents proposals and advice for energy efficiency. Presently, energy efficiency is relatively low in Xiamen, and energy consumption is a little too high, especially in public buildings. The energy consumption of central air conditioning system is very significant, and therefore energy conservation has much potential.

Keywords：public building; energy efficiency;energy consumption of air conditioning; ice-storage.

1. ENERGY CONSUMPTION STATUS OF BUILDINGS IN CHINA

1.1 Energy Consumption

Accoding to the information, building will be developted rapidly in first 20 years of 21 century in China. The national building's area will be two times 2000's at 2020. These buildings will consume large amounts of energy constantly in heating, air conditioning, ventilation, cooking, lighting, hot water supply during the coming decades to nearly 100 years. Figure 1 shows that the growth trends about total energy consumption and building's energy consumption from 1996 to 2001 in China. Figure 2 dispiays that the proportion of energy construction of building increas from 24.1% in 1996 to 27.5% in 2001. And energy consumption of public building is very large proportion. Currently, annual public buildings will be built about 3~4 billion m^2. There are 37 billion m2 public buildings in cities and towns throughout the country in 2003. Thus, energy efficiency of public buildings has been imminent[1].

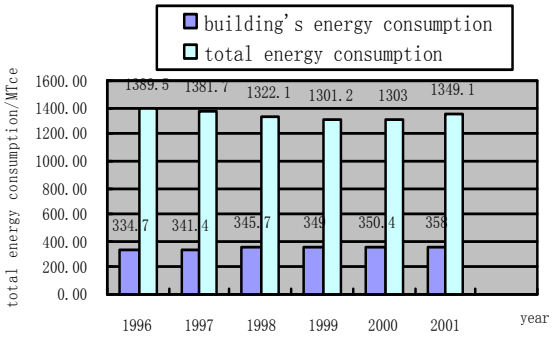

Fig. 1 Increase trend of total energy consumption and building's energy consumption in China

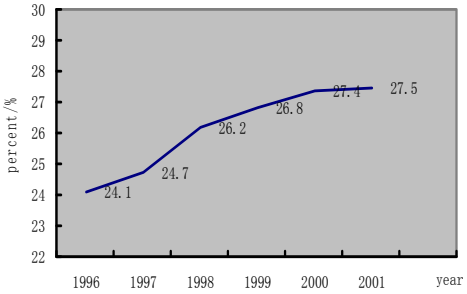

Fig. 2 Proportion of building's energy consumption

1.2 Energy efficiency

"Design standard for energy efficiency of public buildings" (GB50198-2005) provides that, 50% energy efficiency of buildings means that the construction, heating, air conditioning and lighting system will bring about 50% energy efficiency on the

basis of architectural design at local public building in 1980/1981. Heating and air conditioning system will share 20%~16%. If energy efficiency of building is paid attention to from now, design standards about energy efficiency of building is came into force, and existing building is retrofited in order to decrease energy-consumption, the total energy consumption of building can be reduced 3.35 billion tons of standard coal, the peak load of air conditioning can be reduced about 80 million kW, power construction investment would be reduced correspondly 6000 billion yuan[2].

2. ENERGY CONSUMPTION STATUS IN XIAMEN

2.1 Xiamen climate profiles

Xiamen annual average temperature is 20.8 ℃. Accoding to the information, because of the cool and humid southerly wind that is from Pacific, annual average temperature is only 28 in July and August. The highest temperature is 38.4 (August 16, 1953) (Table 1 shows the highest temperature Xiamen in 2004). And in the winter, the average temperature is 12.5 ℃ in January and February, historical minimum temperature is 0 ~1 (February 12, 1957).The days of non-frost season are more than 360 days. The design's day of heating in winter is 0. In addition, the time of sunshine is amounted to 2,276 hours in Xiamen, solar radiation energy is very abundantly. From the division of climate, Xiamen is in typical area that summer is hot and winnter is warm. Table 2 shows summer outdoor design temperature in Xiamen.

Tab. 1 The average monthly maximum temperature of 2004 ( ) in Xiamen

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
16.5	19.8	19.2	24.6	28.5	31.1	32.6	32.8	30.3	27.2	25.1	21.0

Tab. 2 Summer outdoor design temperature in Xiamen（ ）

Ventilation temperature	Air-conditioning temperature	The average temperature of air-conditioning	Hottest month average temperature
31	33.4	29.9	28.4

2.2 Building's status in Xiamen

Xiamen becomes one city of the four special economic zones at October,1980 in China. There are only 8000 million square meters construction area in1985 during the first national census about city and urban building. And 20 years later, the existing-building area has closed to 62.8111 billion square meters by the end of 2004. There has an increase of 54.81 billion square meters, an increase of nearly seven times (*Table 3*). The constructing building area has reached 9362 million square meters (*Table 4*). In the existing buildings, the public building area (except residential, industrial storage, other building) is about size 21.77% of total biulding area .In Constructing buildings, the public building area is about approached to 24.76%.

2.3 Energy consumption profiles in Xiamen

Xiamen's energy consumption structure is coal, electricity and oil in industrial.The proportion is 42.6%,31.7% and 24.5%, respectively in 2003. In 2004, the proportion is 44.4% 29.7% and 24.8% respectively. Because of decrease about the power supply in 2003, power staition generated more power, and consumption of coal is increased. But because of restricted distribution about the electricity for enterprises, electricity consumption is decreased.

In the passing "10th Five-Year Plan" period, investment of construction and transformation about the power grid were accumulated nearly 2 billion yuan in Xiamen. The power grid load reached 1.61 million kW this year in Xiamen. It is 2.04 times to 0.78 million kW which is the highest in 2002. According to Xiamen future development program, electricity consumption is expected to close to 10 billion kWh next year, and it will close to 16.3 billion kWh in 2010. At the same time in 2010, the highest load will close to 3.045 million kW, which will has an increase of 1.432 million kW than 2004. Therefore, the energy efficiency is wery import in

Xiamen.

Tab. 3 Area and uses of existing-building

Functiona	Residential	Industrial Storage	Business Services	Education Research Medical	Culture Sports Entertainment	Office	Other
area (10^4m^2)	3606.79	1188.3	608.68	266.14	76.50	415.51	119.19
proportion	57.42%	18.92%	9.69%	4.24%	1.22%	6.62%	1.9%

Tab. 4 Area and uses of constructing building

Functiona	Residential	Industrial Storage	Business Services	Education Research Medical	Culture Sports Entertainment	Office	Other
area (1×10^4m2)	651.82	49.24	149.56	30.23	11.73	40.21	3.4
proportion	69.62%	5.26%	15.98%	3.23%	1.25%	4.30%	0.36%

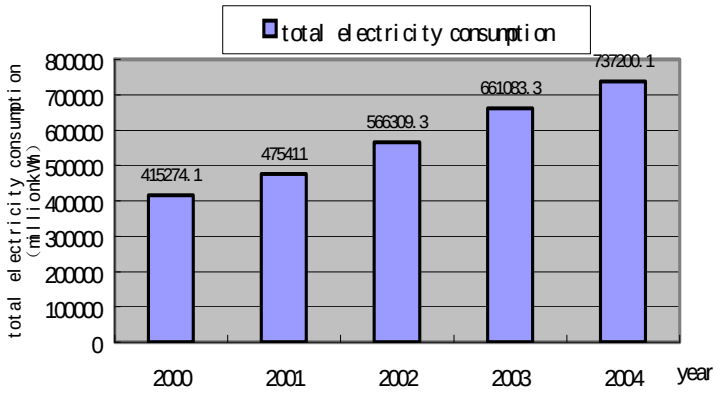

Fig. 3 the total power consumption compared Figure in Xiamen during 2000 and 2004

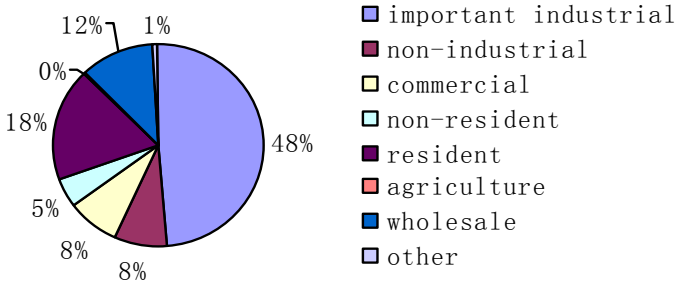

Fig. 4 the electricity distribution maps in Xiamen 2004

2.4 Xiamen air conditioning energy status

Xiamen winter heating period of design calculations is 0 day, the building has't heating in Xiamen (except for a few senior guesthouse). The main energy consumption in building is air conditioning, lighting energy. It can be seen from Table 5, the peak electricity consumption is in the hotest season of the whole year(July, August and September).

For energy consumption in public buildings, air-conditioning causes the biggest energy fluctuations. For the whole year's energy consumption, the lighting, power and other basic load is stability relatively, and the air-conditioning load is fluctuat because of seasonal and climatic factors. When analysis the whole year's energy consumption,

average consumption of two lowest values could be regarded as basic load, while the fluctuat load could be regarded as abasic air-conditioning load. The electricity consumption is 7.38 billion kWh in The air-conditioning energy consumption is about 30.4% in public buildings in Xiamen. This can be drawn from Table 5.While the higest electricity consumption reached 50% in August and September. 2004.If commercial electricity consumption and non-resident electricity consumption in lighting are regarded as public buildings electricity consumption.

According to Xiamen development, construction consumption will increase further, so the potential of energy efficiency in public buildings is enormous in Xiamen.

Tab. 5 Sales electricity per month in 2004 (10^4 kWh)

Category	Jan.	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Important industrial	23323.9	26449.2	28552.0	29567.3	29124.9	31624.8	31576.8	32200.1	33513.3	30342.81	30537.3	29877.9
Non- industrial	3572.24	3003.31	3627.68	3967.90	3780.37	4460.92	4174.50	4476.53	4403.51	3881.35	3995.26	3581.54
Agriculture	3.28	11.58	15.71	10.60	11.17	13.97	16.29	19.19	17.84	12.70	16.17	12.24
Commercial	3406.15	3802.63	3766.75	4254.93	5286.49	6413.79	7032.87	7392.16	7373.16	5678.92	4932.10	4226.47
Resident living	8795.64	9714.28	9148.92	9529.42	9244.15	10885.1	13964.7	14771.2	14371.1	10331.42	9818.32	9459.86
Non-resident lighting	1949.07	2204.39	2244.44	2410.47	2590.05	3418.75	3561.21	3673.07	3779.53	2856.86	2626.82	2567.72
Wholesale	7426.65	7486.26	8397.64	8361.56	9740.91	9858.05	9979.06	10073.6	7974.46	8341.28	9218.63	9082.76
Mutual offset of not clearing	5.72	29.90	42.39	89.17	85.69	252.88	0.00	0.00	0.00	0.00	0.00	0.00
Total	48476.9	52671.7	55753.2	58102.2	59778.1	66675.4	70305.4	72605.8	71432.9	61445.33	61144.6	58808.6

3. PROBLEMS

After the survey to about 20 large public buildings in Xiamen , the author found that the public buildings exists a wide range of issues :

3.1 Design of system is inappropriate generally, and capacity of equipment is relatively large.

In this survey of nearly 20 large buildings, the employed equipment is inappropriate in capacity majority, even with the office buildings, installed capacity per area has great differences. Table 6 shows the statistic item of installed load about several buildings that author studies. As inappropriate choice of capacity to the system, there exist a lot of drawbacks. For example, when the units are all operated the **temperature** of indoor is lower but when the units are part operated the **temperature** of indoor is higer. In such circumstances, the most of the buildings will be to meet the demand for comfortable first and operate all units, this will result in a senseless waste of energy.

Tab. 6 Installed load contrast about air-conditioning unit area of four office buildings

Building	Construction area(m^2)	Installed capacity（RT）	Installed capacity per area (RT/m^2)
A	38000	1000	0.0263
B	62250	1950	0.0313
C	75344	1800	0.0239
D	38000	1400	0.0368

3.2 Operational management unit has no enough awareness for the importance of energy efficiency.The owners are short-sighted and do not focus long-term intention only on the immediate

interests. They have't enough effective measure to retrofit air conditioning systems in energy efficiency. In existing buildings of Xiamen, there are little building that the technology of frequeney conversion are adopted in air-conditioning systems. Furthermore, because of the construction costs, most of the construction units in this survey abandoned the retrofit.

3.3 The government of Xiamen only pay attention to the 99 units which energy consumption is low over 3,000tons of standard coal because of their total electricity consumption is 32.2% but pay inadequate attention to other consumption of electricity units. In the investigation, the majority had not received notice of the government on energy efficiency, or notice is too casually that the owners will not attract anyone's attention. Evidently, the working about energy efficiency of public buildings and enforcement efforts to support the government's policy is very inadequate in Xiamen.

4.METHED OF ENERGY EFFICIENCY[3]

4.1 For finished buildings, recommended that the government shoud strengthen its management of electricity to the high energy consumption building. According to the municipal planning and the life of buiding, economic analysis and retrofit systems in energy efficiency shoud be promoted. The technical and policy support to owners shoud be initiated for strengthening the initiative of retrofit air conditioning systems in energy efficiency.Retrofit work should involve the external security structure, the construction of indoor ventilation, air conditioning and lighting.

4.2 For the buildings in construction, the design standards for energy-efficiency should be strictly followed for and supervision should be strengthened in constructng. The construction project that fails to obey the energy-efficient design standards shoud be denied strongly. Designers should act in accordance with the energy-efficiency design standards.

4.3 The air-conditioning system shoud make use of the smallest percentage of fresh air and the fresh air heat exchanger.

4.4 In order to achieve dynamic regulatory and energy-efficiency under real-time load of Buildings, frequency conversion technology shoud be emploeyed for cooling towers, pumps in central air-conditioning.

4.5 The reasonable air-conditioning temperature shoud be choiced and the dynamic load about air-conditioning system shoud be correctly calculated. By selecting the best combination of equipment and reasonable operational style avoid "big Mara trolleys" resolutely.

4.6 By publicizing ice storage technical, increasing the enthusiasm of useing ice storage. Currently, Xiamen has built only four ice storage air-conditioning systems 。But it is being the government. The important thing will be constructing ice storage air-conditioning systems for private enterprises according to the plan of energy efficiency[4].

5 .CONCLUSION

5.1 This research includes Weather Bureau, Xiamen Electric Power Bureau, Statistics Bureau and many public buildings. The data contains weather info, these years' energy consumption and power consumption, some info of public building area and central air conditioning system.

5.2 Recently, energy efficiency in Xiamen is somewhat low and energy consumption is more than normal. The most serious problem is the energy consumption of central air conditioning system in public buildings.

5.3 It is only in initial stage for energy efficiency project in Xiamen. The importance and technical approach of energy saving is no so publicized. The standard and measure are not carried out yet. The government's policy support is not enough. So it will

be long way to go for energy saving project.

5.4 Energy efficiency is not the most fundamental solution to alleviate resource shortage. We should enhance new energy's research, usage and generalization on base of saving and usage of traditional energy. We expects a potential future for XiaMen's energy saving

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